

AD AO 63874 Special Report 78-30 GROWTH BATES AND CHARACTERISTICS OF ICE ON THE OTTAUQUECHEE AND WINOOSKI BIVERS OF YERMONT DURING WINTER 1977-78, DACA89-78-6-9 David Deck FILE 3 DEPARTMENT OF THE ARMY COLD REGIONS RESEARCH AND ENGINEERING LABORATORY ORPS OF ENGINEERS IANOVER, NEW HAMPSHIRE

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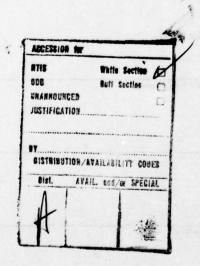
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PREFACE

78-0990 with the U.S. Army Cold Regions Research and Engineering Laboratory. The work was funded by the Directorate of Civil Works, Office, Chief of Engineers. Harman, NH

The ice thickness data reported here were collected by Darryl Calkins, David Deck and Carl Martinson in conjunction with a planned model study of the Ottauquechee River. Additional data will be made available on ice cover progression, water levels, water temperature regime and ice decay, frazil ice, ice jams and remote measurements of ice jams.

Technical review of this report was performed by Darryl Calkins and James Wuebben of CRREL.



INTRODUCTION

During the 1977-78 winter season the growth rates and characteristics of the ice cover were observed on two Vermont rivers, the Ottauquechee River in Quechee and the Winooski River in Middlesex and Montpelier. These observations included measurement of the solid ice and also the amount, if any, of frazil slush ice under the solid cover. The large amounts and the effects of frazil slush produced some interesting and unsuspected data (see Discussion). The river ice thickness data presented in this report will be used in conjunction with a model study of ice jams at the CRREL Ice Engineering Facility.

Appendices A, B and C contain ice thickness data for the two rivers. Appendix D contains representative graphs of ice thickness (η_1) growth rates at selected sites during the third freeze-up of the Ottau-quechee River.

TEST SITES

A portion of the Ottauquechee River near Quechee, Vermont, was the site of the field measurements (Fig. 1). The reach of river studied begins at John Downers Dam in Quechee and continues upstream for approximately 3.2 km (2 miles). This reach consists of 52 cross sections, or stations, 61 m (200 ft) apart, of which 11 cross sections were monitored. The river was surveyed in the summer of 1975, with the dam being designated as 11+00. This survey began 670 m (2200 ft) downstream of the studied reach of river.

The limited ice thickness measurements taken on sections of the Winooski River will be used primarily as a check on a flood prediction report for an ice jam at Middlesex.

The backwater from the Ouechee dam during typical winter flow conditions (300 ft 3 /s) (8.5 m 3 /s) extends up to station 24+00 with a slope in the order of magnitude of 10^{-4} . The remainder of the site has an overall slope of 10^{-3} and includes four rapids sections. These short fast-water reaches have slopes as steep as 10^{-2} .

FREEZE-UP

Three separate ice cover formations occurred on the Ottauquechee in the 1977-78 winter. Shore ice began forming in early December and the initial cover was formed on the morning of 10 December as the frazil slush ice arched over at station 15+00 (Fig. 2-4). The cover quickly progressed upstream to station 30+00 by late afternoon. On the 11th the

cover moved upstream near station 45+00. This initial cover was lost after a severe rain on 8-9 January (Fig. 5). Ice was again formed, in a similar manner, on the 20th. Rain on the 25th caused the cover to jam between stations 15+00 and 22+00, with a new cover beginning to form the same day. This final cover remained until spring melting caused it to go out on 31 March, with no ice jams resulting. The average daily temperatures at Woodstock, Vermont, are plotted in Figures 6 and 7 for the first and third freeze-ups.

EQUIPMENT AND PROCEDURE

Holes were drilled through the ice with a 5.72-cm (2 1/4-in.) auger at selected cross sections at various distances from the river bank (Fig. 8,9). The solid ice was measured with a thickness gauge capable of giving an accuracy to 1/8 in.

Frazil slush ice was detected by four different methods.

- 1. Visual. Slush ice could be readily detected through observation of the ice crystals when the hole was being cleared with the auger, but this gave no idea of the thickness.
- 2. Vane current meter. A meter was lowered down through the slush until it gave indication of a flow velocity, just below the slush ice/free fluid interface, then raised until a zero flow was recorded. The trouble with this type of detection was that the equipment was mechanical and froze up in low air temperatures and malfunctioned if left outside of the fluid environment. The method was also time-consuming.
- 3. Magnetic current meter. The same procedure was used as with the vane meter but there were no moving parts in the fluid and no icing problems. Again the method was time-consuming.
- 4. Impulse radar technique. An impulse radar unit was used to detect solid ice, slush ice, and water interfaces. The unit can be towed across the ice cover behind a snowmobile or by hand. This method was fast and preliminary data show it to be the best means for detecting slush ice.

DISCUSSION

The data are more consistent at some sites than at others because of precise tape-measuring to the same holes from a constant reference. During the first freeze-up, stations 12+00 and 15+00 had all holes drilled in the exact locations designated. The same is true of stations

49+00, 50+50 and 53+00 during the third freeze-up. Holes at the other stations may have been drilled within +1 m on a few occasions, mainly because a heavy snow cover sometimes made it very difficult to find the exact location of the previous hole.

It is believed that greater quantities of solid ice will form in areas where there are large amounts of frazil slush under the solid ice cover than in slush-free areas. The slush ice is already in between the liquid and solid states of water and therefore requires less heat to be removed to form solid ice. The slush ice appears to become a greater factor as the solid cover becomes thicker and it takes a longer time for the heat to be extracted from the ice cover.

Slush ice was also observed to greatly reduce the melting of the underside of the solid ice cover when water temperatures rose to +0.1 to +0.4°C beneath the cover. This is very clear in all the graphs of ice thickness duration in Appendix D. As long as the slush ice remained under the cover it retarded the melting process so that only ice/air surface melting occurred.

This further supports the importance of the role frazil slush ice is performing. The heat from the water that would otherwise be conducted and convected to the solid cover is first used to melt the frazil slush. The areas of frazil slush beneath the cover generally had low flow velocities, again reducing the heat transfer rate.

The following brief summary, for non-slush and slush holes exclusively, shows the increased extent of solid ice growth due to frazil slush beneath the cover.

Sta. 12+00 - 6 Jan 78

65'*Lt. - slush ice 444 mm solid ice (17.5 in.) 104'*Lt. - no slush 419 mm solid ice (16.5 in.)

6% greater growth in slush hole. This began to increase before the cover was lost on the 9th.

Sta. 49+00 - 9 Mar 78

118'Rt. - slush ice 559 mm solid ice (22 in.) 58'Rt. - no slush 384 m solid ice (15.1 in.)

31% greater growth in slush hole.

142'Rt. - slush ice 635 mm solid ice (25 in.)

60% greater growth than in slush-free hole.

*Distance from left (Lt.) or right (Rt.) river bank, looking upstream.

Sta. 50+50 - 2 Mar 78

55'Rt. - slush ice 508 mm solid ice (20 in.)

40'Rt. - no slush 375 mm solid ice (14.75 in.)

26% greater growth in slush hole.

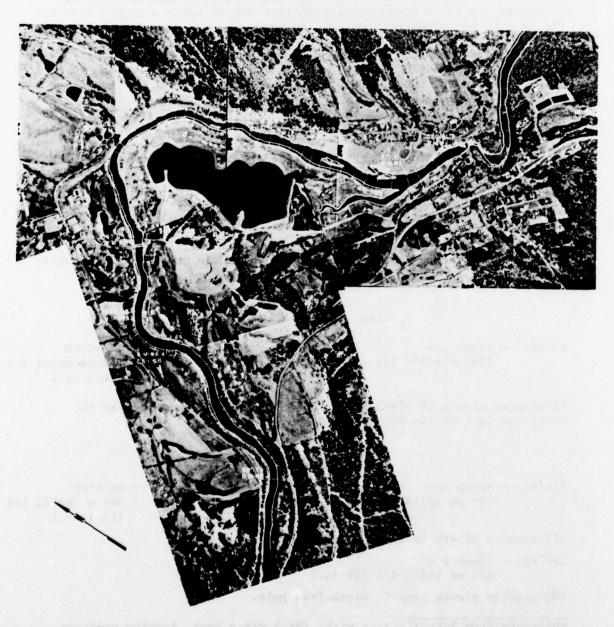


Figure 1. Ottauquechee River showing locations of cross sections.

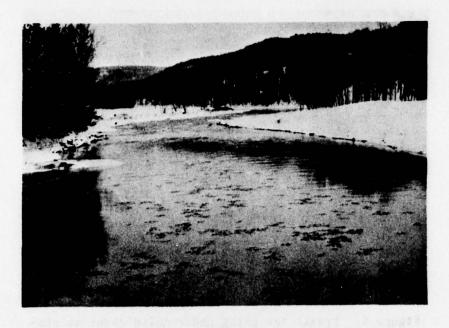


Figure 2. Frazil ice generated in supercooled water near station 55+00, 19 Dec 77.



Figure 3. Ice conditions at station 15+00 prior to arching of initial cover, 9 Dec 77.



Figure 4. Frazil ice going under solid cover at station 53+00, 19 Dec 77.



Figure 5. Ice run of 9 Jan 78 observed at John Downer's Dam.

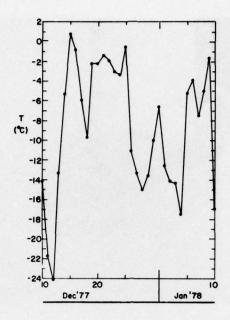


Figure 6. Average daily temperatures in Woodstock, first freeze-up.

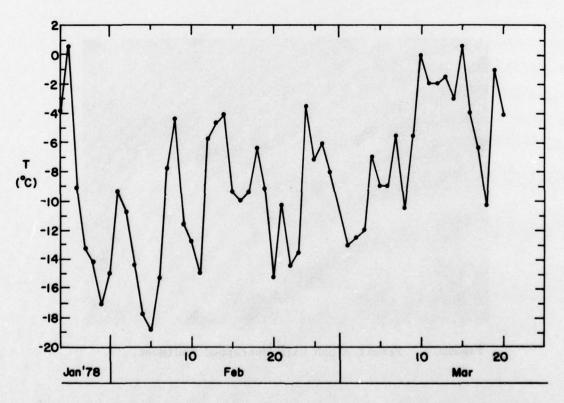


Figure 7. Average daily temperatures in Woodstock, first freeze-up.



Figure 8. Typical ice auger hole with extracted frazil slush around perimeter.

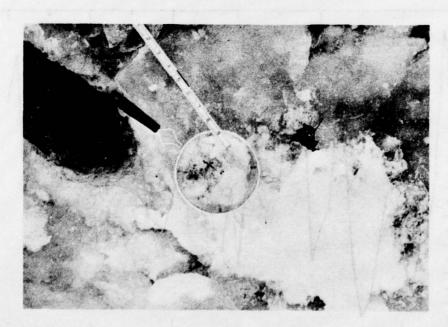


Figure 9. Frazil slush with entrapped sediment.

APPENDIX A: ICE THICKNESS DATA, OTTAUQUECHEE RIVER, FIRST FREEZE-UP.

OTTAUCJECHEE RIVER

Sta. 12+00

	Position*	Ice thi	ckness	Growth		Slush	ice
Date	from rt.	in.	mm	in./day	mm/day	ft	m
12-31-77	17'	14.25	361.95			3.19	0.98
1- 5-78		17.00	431.80	0.55	13.97	X	
1- 6-78		17.25	438.15	0.25	6.35	X	
12-27-77	35'	14.00	355.60			X	
12-29-77		15.50	393.70	0.75	19.05	X	
12-31-77		15.50	393.70	0.00	0.00	5.60	1.71
1- 3-78		15.50	393.70	0	0	X	
1- 5-78		18.00	457.20	1,25	31.75	X	
1- 6-78		19.00	482.60	1.00	25.4	Х	
12-27-77	65'	10.00	254.00			x	
12-29-77		12.75	323.85	1.38	34.92	X	
12-31-77		14.12	358.65	0.68	17.40	X	
1- 3-78		14.12	358.65	0.00	0.00	X	
1- 5-78	**	15.00	381.00	0.44	11.18	X	
1- 6-78		17.50	444.50	2.50	63.50	X	
12-15-77	901	4.12	104.65				
12-22-77	,,,	7.00	177.80	0.41	10.45	X	
12-29-77		12.50	317.50	0.79	19.96	X	
12-31-77		13.00	330.20	0.25	6.35	X	
1- 5-78		15.00	381.00	0.40	10.16	X	
1- 6-78	4.53 . #	15.50	393.70	0.50	12.70	X	
	19 19 19 19 19 19 19 19 19 19 19 19 19 1	mar.	1 052	. 77.6	.01 08		
12-15-77	120'	8.50	215.90				
12-27-77		12.50	317.50	0.33	8.47		
12-29-77		14.62	371.35	1.06	26.92		
12-31-77	87.13	15.75	400.05	0.56	14.35		13-67
1- 3-78	900000000000000000000000000000000000000	15.75	400.05	0	0		- 177-55
1- 5-78		16.75	425.45	0.50	12.70	X	
1- 6-78		17.00	431.80	0.25	6,35	X	
12-15-77	140'	7.44	188.98	T1 - 61.7			-61-51
12-27-77	y trains	13.00	330.20	0.46	11.77		
12-29-77		14.50	368.30	0.75	19.05		- TI-RI
12-31-77		15.12	384.05	0.31	7.87		75-01
1- 3-78		15.50	393.70	0.13	3.22		
1- 5-78		16.25	412.75	0.38	9.52	0.5	
1- 5-78		16.50	419.10	0.25	6.35		

^{# =} Distance (ft) from Right or Left Bank looking upstream.
X = Frazil slush ice present but quantity unknown.

OTTAUQUECHEE RIVER

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ALVER CHETERVILLE

Sta. 15+00

Position*		Ice thi	ckness	Growth	rate	Slush	ice
Date -	from rt.	in.	mm	in./day	mm/day	ft	m
12-29-77	35'	14.00	355.60	- 15 M	177	x	
12-31-77		15.00	381.00	0.50	12.70	X	
1- 3-78		16.38	416.05	0.46	11.68	X	
1- 6-78		16.75	425.45	0.12	3.13	3.45	1.05
12-27-77	751	13.25	336.55	04.84		x	10 Car.
12-29-77	0.0	15.00	381.00	0.88	22.22	X	
12-31-77		15.50	393.70	0.25	6.35	X	
1- 3-78		16.25	412.75	0.25	6.35	X	
1- 6-78		18.75	476.25	0.83	21.17	1.70	0.52
12-27-77	115'	10.25	260.35		120	x	-15-31
12-29-77	77.34	12.00	304.80	0.88	22.22	X	
12-31-77	OF II	13.38	339.85	0.69	17.53	X	
1- 3-78	00.0	14.62	371.35	0.41	10.50	X	-
1- 6-78	11.10	15.00	381.00	0.13	3.22	3.6	1.10

OTTAUQUECHEE RIVER

10:45 19.96 6.35

	Position*	Too th	ickness .	Growth	rate	Slush	100
Date	from rt.	in.	mm	in./day	mm/day	ft	m
			06.516	00.3	1081	177	21-51
12-13-77	130	5.50	139.70	07.91		2.0	0.61
12-22-77	50.36	8.50	215.90	0.33	8.47	X	
12-27-77	27.31	11.00	279.40	0.50	12,70	0	19-31
12-29-77		12.50	317.50	0.75	19.05	0	5 -7
12-31-77	y	13.50	342.90	0.50	12.70	X	
1- 3-78	K. 37.	14.50	368.30	0.33	8.47	0	1- 6-
12-13-77	180'	7.00	177.80	10.0		2.0	0.61
12-22-77	W. A.E.	10.00	254.00	0.33	8.47	X	
12-27-77	275 07	13.50	342.90	0.70	17.78	X	
12-29-77		14.75	374.65	0.62	15.88	X	-11-41
12-31-77		15.88	403.35	0.56	14.35	X	
1- 3-78	93,0	16.00	406.40	0.04	1.02	X	
1- 6-78	48.5	18.00	457.20	0.67	16.93	x	

. Translation (ft) from flight of Loft hank tooking until the X

0

Sta. 25+70

osition*	Ice th	lckness	Growth	rate	Slush	ice
from rt.	in.	nen	in./day	mm/day	ft	m
35'	6.25	158.75	349165 - 7	*moist	0	0
Carlo Vech	6.25	158,75	0.11	0,3 10.	2.80	0.85
	8.00	203.20	0.19	4.94	X	
	12.75	323.85	0.95			66-17
91.54	13.88	352.55				1 -91
	15.00			14.35		
	16.12					0 -1
	17.25	438.15	0.38	9.57	X	00
80'	8.25	209.55			x	11.0
			0	0	0.83	0.25
CS-3				13.49		0 -1
	18.00	457.20	0.25	6.35	X	
170'	4.00	101.60	9000年10年————————————————————————————————		x	
			0	0	1.69	0.52
			0.41	10.43	X	
		292.10	0.88	22,22	X 2.2	
radian.	15.38	390.65	1.94	49.28	X	
***	20.50	520.70	0.85	21.67	0	-
		08.E	F 00.F			91-51
190'	12.50	317.50	NS 75-01		X	
					X	
	19.00	482.60	1.08	27.52	X	
	80°	80' 8.25 16.75 18.00 16.12 17.25 80' 8.25 16.75 18.00 170' 4.00 9.75 11.50 15.38 20.50	from rt. in. mm 35' 6.25 158.75 8.00 203.20 12.75 323.85 13.88 352.55 15.00 381.00 16.12 409.45 17.25 438.15 80' 8.25 209.55 8.25 209.55 16.75 425.45 18.00 457.20 170' 4.00 101.60 4.00 101.60 9.75 247.65 11.50 292.10 15.38 390.65 20.50 520.70 190' 12.50 317.50 14.25 361.95	from rt. in. mm in./day 35' 6.25 158.75 0 8.00 203.20 0.19 12.75 323.85 0.95 13.88 352.55 0.56 15.00 381.00 0.56 16.12 409.45 0.37 17.25 438.15 0.38 80' 8.25 209.55 0 8.25 209.55 0 0 16.75 425.45 0.53 0.53 18.00 457.20 0.25 170' 4.00 101.60 0 9.75 247.65 0.41 11.50 292.10 0.88 15.38 390.65 1.94 20.50 520.70 0.85 190' 12.50 317.50 14.25 361.95 0.88 15.75 400.05 0.30	from rt. in. mm in./day mm/day 35' 6.25 158.75 0 0 8.00 203.20 0.19 4.94 12.75 323.85 0.95 24.13 13.88 352.55 0.56 14.35 15.00 381.00 0.56 14.35 15.00 381.00 0.56 14.35 16.12 409.45 0.37 9.48 17.25 438.15 0.38 9.57 80' 8.25 209.55 0 0 8.25 209.55 0 0 0 16.75 425.45 0.53 13.49 18.00 457.20 0.25 6.35 170' 4.00 101.60 0 0 9.75 247.65 0.41 10.43 11.50 292.10 0.88 22.22 15.38 390.65 1.94 49.28 20.50 520.70 0.85 21.67 190' 12.50 317.50 0.88 22.22 <td>from rt. in. mm in./day mm/day ft 35' 6.25 158.75 0 0 2.80 8.00 203.20 0.19 4.94 X 12.75 323.85 0.95 24.13 X 13.88 352.55 0.56 14.35 X 15.00 381.00 0.56 14.35 X 16.12 409.45 0.37 9.48 X 17.25 438.15 0.38 9.57 X 80' 8.25 209.55 0 0 0 0.83 16.75 425.45 0.53 13.49 X 18.00 457.20 0.25 6.35 X 170' 4.00 101.60</td>	from rt. in. mm in./day mm/day ft 35' 6.25 158.75 0 0 2.80 8.00 203.20 0.19 4.94 X 12.75 323.85 0.95 24.13 X 13.88 352.55 0.56 14.35 X 15.00 381.00 0.56 14.35 X 16.12 409.45 0.37 9.48 X 17.25 438.15 0.38 9.57 X 80' 8.25 209.55 0 0 0 0.83 16.75 425.45 0.53 13.49 X 18.00 457.20 0.25 6.35 X 170' 4.00 101.60

OTTAUQUECHEE RIVER

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ob ice

	Position*	Ice th	ickness	Growth	rate	Slush ice
Date	from rt.	in.	tum	in,/day	mm/day	ft m
		0.0	10.89			19-61-51
12-13-77	401.0.11	6.25	158.75	20.7		5.31 1.62
12-22-77	F0.01	8.50	215.90	0.25	6.35	X
12-27-77		12.75	323.85	0.85	21.59	X
12-29-77		15.00	381.00	1.12	28.58	X TO DE LOT
12-31-77	50.11	15.50	393.70	0.25	6.35	X
1- 3-78	£	16.00	406.40	0.17	4.23	X
1- 6-78		18.00	457.20	0.67	16,93	2,88 0.88
			00.88		tor	Pharter.
12-12-77	100	9.00	228.60	67.7		3.67 1.12
12-22-77	58, 41	12.00	304.80	0.30	7.62	X
12-27-77	100.55	15.50	393.70	0.70	17.78	X
12-29-77	43.0	17.50	440.50	1.00	25.40	X
12-31-77	26.00	18.50	469.90	0.50	12.70	XAV.
1- 3-78		18.75	476.25	0.08	2.12	X
1- 6-78		18,75	476.25	0	0	X

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Sta. 30+00

from rt.	in.				
		mm .	in./day	mm/day	ft m
40 ·	8.00 15.00 15.75	203.20 381.00 400.05	0.78	19.76 6.35	X X
83.0	16.25	412.75	0.17	4.23	X
100'	8.00	203.20	17.125		****
			0,82	20.83	Χ
90.81	15.38 16.00	390.65 406.40	0.21	5.25	X
	35.41 35.41 9.48 76.0	15.00 15.75 16.25 100' 8.00 15.38 15.38	15.00 381.00 15.75 400.05 16.25 412.75 100' 8.00 203.20 15.38 390.65 15.38 390.65	8.00 203.20 15.00 381.00 0.78 15.75 400.05 0.25 16.25 412.75 0.17 100' 8.00 203.20 15.38 390.65 0.82 15.38 390.65 0 16.00 406.40 0.21	8.00 203.20 15.00 381.00 0.78 19.76 15.75 400.05 0.25 6.35 16.25 412.75 0.17 4.23 100' 8.00 203.20 15.38 390.65 0.82 20.83 15.38 390.65 0 0 16.00 406.40 0.21 5.25

OTTAUQUECHEE RIVER

Sta. 31+00

1.49 0.72

17-5%-57 17-63-77

7,	Position*	Ice thi	ckness 1	Growth	rate	Slush ice
Date '	from rt.	in.	mm dia dia	in./day.	mm/day	ft m
- 0	10.45	(3.0	07.198	06.05		67-0-73
12-12-77	75'	7.00	177.80			5.83 1.78
12-13-77 ×		10.25	260.35	3.25	82.55	5.83 1.78
	58.88	58.0	74.100	281. (1)		17-09-01
	50.7	0.30	20.001	15.75		87-7
	10.10	w.	(0.7%)	00.01		37.3 -
2				and the same of th		

OTTAUQUECHEE RIVER

, Sta. 37+00

	Position*	Ice thi	ckness" . sc	Growth	rate	Slush ice
Date	from lt.	in.	mm	in./day	mm/day	ft m
19.70	258		TO STEE	otela not	*anicle	•9
12-12-77	201:	3.25	82.55		POR POR	1 0 avail
12-13-77		3,50	88.90	0.25	6.35	Ö
12-21-77		7.25	184,15	0.47	11.9104	12-11-110
12-27-77	12.0	10.25	260.35	0.67	16.93	0 17-2-1
X	67.45	20,0	28.ESF	18.75		17-78-91
12-29-77	35112.1	12.25	311.15.15	15.00		077-98-01
1- 3-78	25.0	14.50	368.30	0.45	11.43	0 17 - 17 - 7 1
1- 6-78	19.4	15.00	381.00	0.17	4.23	087-2-1
69.0 60.9	16.93.	re.o	09.124	28.00		25-9 -1
12-12-77	70'	3.50	88.90			X
12-21-77		7.50	190.50.	0.44	11.29	4.06 1.24
12-27-77	2964	11.00	279.40	0.58	14.82	X
12-29-77	87.1	12.00	304.80	0.50	12.70	X 17-18-12
1- 3-78	04.75	12.50	317.50.00	0.10	2.54	X YC- S-S
1- 6-78	CY.31	14,50	368.30	0.67	16.93	X 77-16-55
X	81.8	80.0	85.074	16.75		60-6-1
*	ø	. 0	196.35	18.75		87-8 -1

Sta. 3	7+00	cont'd	.)
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Sta. 37+00	(cont'd)				(b'droo	Sta. 89405 (
12-12-77	105'	3.50	88.90	08.8	107	170.75.07
12-21-77	88,08	7.00	177.80	0.39	9.88	1.70 0.52
12-29-77		12.00	304.80	0.62	15.88	X
1- 3-78		12.25	311.15	0.05	1.27	X
1- 6-78		14.75	374.65	0.83	21.17	X
0			01.02			112-21-11
12-21-77	115'	7.00	177.80			1.70 0.52
12-29-77		11.50	292.10	0.56	14.29	X
1- 3-78		12.00	304.80	9.10	2.54	0
1- 6-78		14.00	355.60	0.67	16.93	X

Sta. 45+00

	Position*	Ice thi	ckness	Growth	rate	Slush	ice
Date	from lt.	in.	mm	in./day	mm/day	ft	m
12-12-77	35'	3.50	88.90			0	
12-13-77		3.50	88.90	0	0	0	
12-22-77		6.50	165.10	0.33	2.47	X	
12-27-77		16.00	406.40	1.90	48.26	0	
12-29-77		18.00	457.20	1.00	25.40	X	
1- 3-78		18.00	457.20	0	0	0	
1- 6-78		19.25	488.95	0.42	10.58	X	
	20.01		27.47	27.61			-
12-12-77	70'	3.25	82.55			0	
12-22-77		6.50	165.10	0.32	8.25	X	
12-27-77	35.01	11.00	279.40	0.90	22.86	0	Y
12-29-77	12.85	13.00	330.20	1.00	25,40	X	1.
1- 3-78	77.45	14.50	368.30	0.30	7.62	X	1 -1
1- 6-78	,	15.25	387.35	0.25	6.35	X	
7			(a), (c)	(30), 4	10.0	17-1	4
12-12-77	105'	3.00	76.20	00.0		X	1
1- 3-78	71.15	22.00	558.80	0.86		X	1 - 1
1- 6-78		22.50	571.50	0.17	4.23	X	

OTTAUQUECHEE RIVER

Sta. 49+00

	Position*	Ice thi	ckness	Growth	rate	Slush	ice
Date	from 1t.	in.	mm	in./day	mm/day	Tt.	m
12-27-77	35'	8.50	215.90			x	
1- 3-78		11.75	298.45	0.46	11.79	0	
1- 6-78		14.50	368.30	0.92	23.28	0	

Sta.	49+00	(cont'd)	
		701	

12-27-77	70'	8.50	215.90	3.50	*20.0	X 1 1 - 1 - 1 - 1 - 1
12-29-77	88.0	13.75	349.25	2.62	66.68	X
1- 3-78	£3.81	14.00	355.60	0.05	1.27	X17-05-55
1- 6-78	rs.J	17.00	431.80	1.00	25.40	X 57-8 -1
X	21.17	11.0	20.875	77.41		1- 6-78
12-27-77	105'	8.00	203.20			0
12-29-77		10.38	263.65	1.19	30.23	X
1- 3-78	65.41	15.25	387.35	0.97	24.74	0.
1- 6-78	4	16.50	419.10.	0.42	10.58	0
			00 000	MILL TO		

Com. 37+00 (comp'd)

OTTAUQUECHEE RIVER

Sta. 53+00

			The Company of the Co			
	Position*	Ice thi	ckness	Growth	rate	Slush ice
Date	from lt.	in.	mm and and	in./day	mm/day	ft m
	77 77,0111,500	vab .a		T.	.di mor	Dated
12-27-77	35'	10.75	273.05			X
12-29-77		13.00	330.20	1.12	28.58	X
1- 3-78	C	14.00	355.60	0.20	5.08	0
1- 6-78	14.5	14.75	374.65	0.25	6.35	0 1-
1	10.25	00.1	0.1.304	00.81		77-75-52
12-22-77	55	4.00	101.60	18.00		X
12-27-77	1	8.00	203.20	0.80	20.32	0
12-29-77	Re-ot-	11.00	279.40	1.50	38.10	X 31-0 -1
1- 3-78		14.75	374.65	0.75	19.05	Χ .
			ec. 56.	82.6	.01	17-51-51
12-22-77	70'	4.00	101.60	02.0		X These-si
12-27-77	1 30.33	6.00	152.40	0:40	10.16	X
12-29-77	04.48	9.00	228.60.	1.50	38.10	X 765- 1
1- 6-78	53.7	18.25	463.55	1.16	29.37	X OT-E -L
	6.35	1.85	25.785	15.25		87-8 -1
12-22-77	110'	4.00	101.60			X
1- 3-78 .	<u> </u>	9.00	228.60	0.42	10.58' 01	X
1- 6-78		11.50	292.10	0.83	21.17	X ST-F-I
	(20,4	F4.0	00.173	02.55		1 - 6-78

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12-87-71 1- 3-78 1- 6-78

35'

01.14 04.0 00.85 02.8 01.14 04.0 00.85 02.14 02.20 08.0 08.60

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APPENDIX B: ICE THICKNESS DATA, OTTAUQUECHEE RIVER, THIRD FREEZE-UP. Sta. 25+70

	Position	Ice thi	ckness	Growth	rate	Slush	ice	Snow o	over
Date	from rt.	in.	mm	in./day	mm/day	ft	m	ft	m
2-23-78	17'	18.50	469.90			2.30	0.70		
3- 2-78	The second	20.50	520.70	0.28	7.26	X			
3- 9-78		23.75	603.25	0.46	11.79	X		0.17	0.05
3-14-78		24.50	622.30	0.15	3.81	X			
3-20-78		24.00	609.60	-0.08	-2.12				
3-22-78		20.00	508.00	-2.00	-50.80				
			11.						
2- 1-78	35'	5.75	146.05			X			
2- 6-78		13.25	336.55	1.50	38.10				
2- 1-78	90'	13.00	330.20			х			
2- 6-78		16.00	406.40	0.60	15.24	X			
2-23-78	105'	32.50	825.50			1.72	0.52		
3- 2-78		33.50	850.90	0.14	3.63	X			
3- 9-78		33.50	850.90	0	0	X		0.17	0.05
3-14-78		32.25	819.15	-0.25	-6.35	X			
2- 1-78	170'	9.50	241.30			x			
2- 6-78		16.00	406.40	1.30	33.02	X			

Sta.	27+00
s	Gro
-	-

			DUCE						
	Position	Ice thi	ckness	Growth	rate	Slush	ice	Snow o	over
Date	from rt.	in.	mm	in./day	mm/day	ft	m	ft	m
2- 1-78	40.	12.00	304.80			x			
2- 6-78		17.00	431.80	1.00	25.40	X			
3- 2-78		27.00	685.80	0.42	10.58	. X			
3- 9-78		31.50	800.10	0.64	16.33	X		0.25	0.08
3-14-78		34.25	869.95	0.55	13.97	X			
3-20-78		29.00	736.60	-1.05	-26.67				
3-24-78		26.00	660.40	-0.75	-19.05				
2- 1-78	90'	6.50	165.10			0			
2- 6-78		12.25	311.15	1.15	29.21	X			

Sta. 30+00

	Position	Ice thi	ckness	Growth	rate	Slush	ice	Snow c	over
Date	from .lt.	in.	mm.	in./day	mm/day	ft	`m	ft	m
2- 1-78	70'	9.50	241.30			5.00	1.52		
2- 6-78	73.11	10.25	260.35	0.15	3.81	X			
2-16-78		16.00	406.40	0.58	14.60	X			
3- 2-78		21.00	533.40	0.38	9.07	X		0.75	0.23
3- 9-78		21.75	552.45	0.11	2.72	X		0.50	0.15
3-14-78		21.00	533.40	-0.15	-3.81	X			
3-20-78		21.00	533.40	0		X			
3-24-78		20.50	520.70	-0.12	-3.18				

OTTAUQUECHEE RIVER

Sta. 37+00

	Position	Ice thi	ckness	Growth	rate	Slush	ice	Snow	cover
Date	from 1t.	in.	mm	in./day	mm/day	ft	m	ft	m
2- 1-78	25'	4.50	114.30		6				
2- 6-78		11.00	279.40	1.30	33.02				
2-16-78		17.00	431.80	0.60	15.24				
2-23-78		20.00	508.00	0.43	10.88				
3- 2-78		26.25	666.75	0.89	22.68				
3- 9-78		26.00	660.40	-0.04	-0.91				
3-14-78		24.00	609.60	-0.40	-10.16				
3-20-78		15.00	381.00	-1.50	-38.10				
0									
2- 1-78	65'	6.00	152.40		/	X			
2- 6-78		13.00	330.20	1.40	35.56	X			
2-16-78		16.75	425.45	0.38	9.52	X			
2-23-78		18.25	463.55	0.21	5.44	X			
3- 2-78		20.50	520.70	0.32	8.16	X			
3- 9-78		20.00	508.00	-0.07	1.81	X		0.50	0.15
3-14-78		20.00	508.00	0		X			100
3-20-78		20.00	508.00	. 0		X			
2- 1-78	105'	6.00	152.40			x			
2- 6-78		13.50	342.90	1.50	38.10	X			
2-16-78		17.00	431.80	0.35	8.89	x			
2-23-78		24.00	609.60	1.00	25.40	X X			
3- 2-78		26.00	660.40	0.28	7.26				
3- 9-78		25.75	654.05	-0.04	-0.91				
3-14-78		23.50	596.90	-0.45	-11.43				
3-20-78		23.50	596.90	0		*			

OTTAUQUECHEE RIVER

Sta. 38+00

	Position	Ice thi	ckness	Growth	rate	Slush	ice		cover
Date	from 1t.	in.	mm	in./day	mm/day	ft	m	ft	m
3- 9-78	31'	16.00	406.40						
3-14-78	3.	15.50	393.70	-0.10	-2.54				
3-22-78		13.00	330.20	-0.31	-7.94				
3-24-78		8.50	215.90	-2.25	-57.15				
2-23-78	41'	24.00	609.60						
3- 9-78		19.00	482.60	-0.36	-9.07	X			
3-14-78		19.00	482.60	0		X			
3-22-78		19.00	482.60	0					
3-24-78		19.00	482.60	0		Х			
00 70	561	21.00	533.40						
2-23-78	20.			0.00	0 1.5				
2- 9-78		21.25	539.75	0.02	0.45				
2-14-78		20.00	508.00	-0.25	-6.35				
3- 9-78	62'	22.75	577.85						
3-14-78		16.00	406.40	-1.35	-34.29				
2-23-78	71'	18.00	457.20						
	11.	19.75	501.65	0.12	3.18				
3- 9-78		18.00	457.20	-0.35	-8.89	-1			
3-14-78		10.00	451.20	-0.35	-0.09				
3- 9-78	86'	21.00	533.40			X			
3-14-78		20.00	508.00	-0.20	-5.08	X			
02.470	116'	00 50	520.70			v			
2-23-78	110.	20.50		0.01	c 1.1.	X			Byen
3- 9-78		17.50	444.50	-0.21	-5.44	X			
3-14-78		17.50	444.50	0	THE RELL	X			
2-23-78	136'	20.00	508.00			X			
3- 9-78		26.50	673.10	0.46	11.79				
3-14-78		21.50	546.10	-1.00	-25.40				

OTTAUQUECHEE RIVER

Sta. 45+00

	Position	Ice this	ckness	Growth	rate	Slush	ice	Snow	cover
Date	from 1t.	in.	non	in./day	mm/day	ft	m	ft	m
2- 1-78	35'	5.50	139.70			x			
2- 6-78		12.75	323.85	1.45	36.83				
2-16-78		16.75	425.45	0.40	10.16	X			
3- 2-78		27.50	698.50	0.77	19.50	X			
3- 9-78		27.50+	Ice Grounde	d					
3-14-78		27.50+	" "						

-		
Ste	1.5400	(cont'd)
DUG.	4) 100	(COILC O

2- 1-78	70'	0.88	22.35			x
2- 6-78		8.25	209.55	1.47	37.44	
2-16-78		12.00	304.80	0.38	9.52	
2-23-78		18.25	463.55	0.89	22.68	
3- 2-78		27.00	685.80	1.25	31.75	
3- 9-78		25.50	647.70	-0.21	-5.44	
3-14-78		21.50	546.10	-0.80	-20.32	
2- 6-78	105'	11.75	298.45			x
2-16-78		16.00	406.40	0.42	10.80	X
2-23-78		21.25	539.75	0.75	19.05	X
3- 2-78		23.75	603.25	0.36	9.07	X
3- 9-78		22.50	571.50	-0.18	-4.54	

Sta. 49+00

	Position	Ice thi	ckness	Growth	rate	Slush	ice	Snow	cover
Date	from 1t.	in.	mm	in./day	mm/day	ft	m	ft	m
2-16-78	10'	18.00	457.20			1.42	0.43		
2-23-78		21.50	546.10	0.50	12.70				
2-16-78	20'	11.50	292.10						
2-23-78		11.50	292.10						
3- 2-78		13.00	330.20	0.21	5.44				
3- 9-78		16.25	412.75	0.46	11.79			0.25	0.08
3-14-78		15.25	387.35	-0.20	-5.08				
3-20-78		13.50	342.90	-0.29	-7.41				
3-22-78		9.25	234.95	-2.12	-53.98				
3-23-78		8.50	215.90	-0.75	-19.05				
2-16-78	28'	9.00	228.60						
2-23-78		12.50	317.50	0.50	12.70				
3- 2-78		14.00	355.60	0.21	5.44				
3- 9-78		18.25	463.55	0.61	15.42				
3-14-78		15.00	381.00	-0.65	-16.51				
3-20-78		10.00	254.00	-0.83	-21.17				
3-22-78		7.00	177.80	-1.50	-38.10				
3-23-78		6.00	152.40	-1.00	-25.40				
2- 6-78	37'	6.75	171.45			x			
2-16-78		8.75	222.25	0.20	5.08				
2-23-78		11.50	292.10	0.39	9.98.				
3- 2-78		12.00	304.80	0.07	1.81				
3- 9-78		15.50	393.70	0.50	12.70				
3-14-78		13.25	336.55	-0.45	-11.43				
3-20-78		7.00	177.80	-1.04	-26.46				
3-22-78		7.00	177.80	0		100 NO.			
3-23-78		6.25	158.75	-0.75	-19.05				

Sta.	49+00	(cont'd)

2-16-78	47'	9.50	241.30			2.95	0.90	
2-23-78		11.50	292.10	0.29	7.26			
3- 2-78		12.25	311.15	0.11	2.72			
3- 9-78		14.00	355.60	0.25	6.35			
3-14-78		11.75	298.45	-0.45	-11.43			
3-20-78		7.00	177.80	-0.79	-20.11			
3-22-78		6.00	152.40	-0.50	-12.70			
3-23-78		5.00	127.00	-1.00	-25.40			
3-23-10		7.00	121.00	-1.00	-27.40			
2-23-78	54 *	11.00	279.40					
3- 2-78	,	12.50	317.50	0.21	5.44			
3- 9-78		13.50	342.90	0.14	3.63		0.17	0.05
3-14-78		11.50	292.10	-0.40	-10.16		0.1	0.07
3-20-78		10.25	260.35	-0.21	-5.29			
3-22-78		10.00	254.00	-0.12	-3.18			
3-23-78		9.50	241.30	-0.50	-12.70			
3-23-10		9.50	241.30	-0.70	-12.10			
3- 2-78	581	14.50	368.30	0.09	2.25		0.17	0.05
3- 9-78		15.12	384.05	-0.42	-10.77			
3-14-78		13.00	330.20	-0.33	-8.47			
3-22-78		10.00	254.00	-0.50	-12.70			
3-23-78		9.25	234.95	-0.75	-19.05			
3-24-78		9.00	228.60	-0.25	-6.35			
3-25-78		7.00	177.80	-2.00	-50.80			
3-27-10		1.00	111.00	2.00	,			
2-1.6-78	61'	9.00	288.60			2.94	0.98	
2-23-78		14.00	355.60	0.71	18.14	X		
3- 2-78		19.00	482.60	0.71	18.14			
3- 9-78		18.50	469.90	-0.07	-1.81		0.17	0.05
3-14-78		15.50	393.70	-0.60	-15.24			
3-20-78		13.00	330.20	-0.42	-10.58			
3-22-78		12.00	304.80	-0.50	-12.70			
3-23-78		11.50	292.10	-0.50	-12.70	1		
3-24-78		10.50	266.70	-1.00	-25.40			
3-25-78		9.00	228.60	-1.50	-38.10			
3 - 7 - 10		,	220.00		3			
2-16-78	74 '	10.75	273.05			2.83	0.86	
2-23-78		14.00	355.60	0.46	11.79	X		
3- 2-78		16.50	419.10	0.36	9.07	X		
3- 9-78		16.75	501.65	0.46	11.79	X	0.17	0.05
3-14-78		19.00	482.60	-0.15	-3.81	X		
3-20-78		19.00	482.60	0		X		
3-22-78		18.75	476.25	-0.12	-3.18			
3-23-78		18.50	469.90	-0.25	-6.35			
3-24-78		14.50	368.30	-4.00	-101.60			
3-25-78		12.00	304.80	-2.50	-63.50			
The state of the s								

Sta.	49+00	(cont	a)

2- 6-78	961	7.00	177.80			X			
2-16-78		16.62	422.15	0.96	24.43	2.20	0.67		
2-23-78		16.75	425.45	0.02	0.47	X			
3- 2-78		18.00	457.20	0.18	4.53	X			
3- 9-78		20.50	520.70	0.21	5.44	X		0.08	0.02
3-14-78		20.00	508.00	-0.10	-2.54	X			
3-20-78		18.75	476.25	-0.21	-5.29				
3-22-78		15.00	381.00	-1.88	-47.62				
3-23-78		13.50	342.90	-1.50	-38.10				
3-24-78		11.00	279.40	-2.50	-63.50				
3-25-78		9.00	338.60	-2.00	-50.80				
2-16-78	118'	16.00	406.40			1.75	0.53		
2-23-78		21.00	533.40	0.71	18.14	X			
3- 2-78		21.00	533.40	0		X			
3- 9-78		22.00	558.80	0.14	3.63	X			
3-14-78		22.00	558.80	0		X			
3-20-78		20.00	508.00	-0.33	-8.47				
3-22-78		13.50	342.90	-3.25	-82.55				
3-23-78		11.50	292.10	-2.00	-50.80	1000			
3-24-78		10.00	254.00	-1.50	-38.10				
3-25-78		7.00	177.80	-3.00	-76.20				
2- 6-78	142'	7.00	177.80						
2-16-78		15.75	400.05	0.88	22.22	2.31	0.70		
2-23-78		20.50	520.70	0.68	17.24	X			
3- 2-78		25.00	635.00	0.64	16.33	X			
3- 9-78		25.00	635.00	0	1000,080	x			
3-14-78		22.00	558.80	-0.60	-15.24				
3-20-78		18.00	457.20	-0.67	-16.93				
3-22-78		9.50	241.30	-4.25	-107.95				
3-23-78		8.50	215.90	-1.00	-25.40	in the			
					H-BI GOO!				

Sta. 50+50

	Position	Ice thi	ckness	Growth	rate	Slush	ice	Snow o	over
Date	from 1t.	in.	mm	in./day	mm/day	ft	m	ft	m
2-16-78	40'	14.50	368.30						
2-23-78		14.50	368.30	0					
3- 2-78		14.75	374.65	0.04	0.91				
3- 9-78		16.75	425.45	0.29	7.26			0.25	0.08
3-14-78		13.75	349.25	-0.60	-15.24				
3-20-78		6.75	171.45	-1.17	-29.63				

Sta. 50+50	(cont'd)							
2-16-78 2-23-78 3- 2-78 3- 9-78 3-14-78 3-20-78 3-22-78	50'	10.50 12.50 14.00 14.50 11.00 10.00 9.50	266.70 317.50 355.60 368.30 279.40 254.00 241.30	0.29 0.21 0.07 -0.70 -0.20 -0.25	7.26 5.44 1.81 -17.78 -5.08 -6.35	X	0.25	0.08
2-16-78 2-23-78 3- 2-78 3- 9-78 3-14-78 3-20-78 3-22-78 3-23-78	52'	10.50 17.00 16.00 15.75 12.25 12.00 11.00	266.70 431.80 406.40 400.05 311.15 304.80 279.40 254.00	0.93 -0.14 -0.04 -0.70 -0.04 -0.50 -1.00	23.59 -3.63 -0.91 -17.78 -0.91 -12.70 -25.40	X X	0.25	0.08
2-16-78 2-23-78 3- 2-78 3- 9-78 3-14-78 3-20-78 3-22-78 3-23-78	55'	15.00 18.75 20.00 20.50 15.50 13.50 13.50	381.00 476.25 508.00 520.70 393.70 342.90 342.90 317.50	0.54 0.18 0.07 -1.00 -0.33 0	13.61 4.54 1.81 -25.40 -8.47	X X X		
3- 9-78 3-14-78 3-20-78 3-22-78 3-23-78	60'	17.00 17.00 16.00 14.00 13.25	431.80 431.80 406.40 355.60 336.55	0 -0.17 -1.00 -0.75	-4.23 -25.40 -19.05	x	0.33	0.10
3-14-78 3-20-78 3-22-78 3-23-78	65'	14.75 13.50 13.00 12.00	374.65 31.2.90 330.20 304.80	-0.21 -0.25 -1.00	-5.29 -6.35 -25.40	x		

Sta. 53+00

	Position	Ice thi	ckness	Growth	rate	Slush	ice	Snow c	over
Date	from lt.	in.	nyn	in./day	mm/day	ft	m	ft	m
2- 6-78	40'	6.75	171.45			x			
2-16-78		7.50	190.50	0.08	1.90	X			
2-23-78		12.50	317.50	0.71	18.14	4.78	1.44		
3- 2-78		16.00	406.40	0.50	12.70	X			
3- 9-78		17.00	431.80	0.14	3.63	X		0.25	0.08
3-14-78		18.75	476.25	0.35	8.89	X			
3-20-78		17.75	450.85	-0.20	-5.08	X			
3-22-78		17.50	450.85	0					
3-23-78		16.00	406.40	-1.50	-38.10	X			
3-24-78		16.00	406.40	0		X			

Sta.	53+00	(cont'd)	١

2- 6-78 2-16-78 2-23-78 3- 2-78 3- 9-78 3-14-78 3-20-78 3-22-78 3-23-78 3-24-78	75'	6.75 8.00 12.50 15.00 17.75 17.00 15.25 15.25 13.50 11.00	171.45 203.20 317.50 381.00 450.85 431.80 387.35 387.35 342.90 279.40	0.12 0.64 0.36 0.39 -0.15 -0.29 0 -1.75 -2.50	3.18 16.33 9.07 9.98 -3.81 -7.41 -44.45 -63.50	x 3.36 x x x x	1.02	0.25	0.08
3- 2-78 3- 9-78 3-14-78 3-20-78 3-22-78 3-23-78 3-24-78	90'	16.00 17.25 18.25 19.00 17.50 15.00	406.40 438.15 463.55 482.60 444.50 381.00 381.00	0.18 0.20 0.12 -0.75 -2.50	4.54 5.08 3.18 -19.05 -63.50	X X X		0.25	0.08
2-16-78 3- 2-78 3- 9-78 3-14-78 3-20-78 3-22-78 3-23-78 3-24-78	100'	8.50 16.25 19.25 19.75 19.50 17.75 17.75	215.90 412.75 488.95 501.65 495.30 450.85 450.85	0.55 0.43 0.10 -0.04 -0.88 0	14.06 10.88 2.54 -1.06 -22.22	X X X X X		0.25	0.08
2- 6-78 2-16-78 2-23-78 3- 2-78 3- 9-78 3-14-78 3-20-78 3-22-78 3-23-78	115'	6.75 7.50 15.50 16.25 19.00 18.50 17.25 16.50	171.45 190.50 393.70 412.75 482.60 469.90 438.15 419.10 330.20	0.08 1.14 0.11 0.39 -0.10 -0.21 -0.38 -3.50	1.90 29.03 2.72 9.98 -2.54 -5.29 -9.52 -88.90	X 3.43 X	1.04		
2-16-78 2-23-78	130'	4.00	101.60 304.80	1.14	29.03	х			

PR. 232 17 A DELPHI US 1 PR. ASE ASES CA. ASE ASES 25. US DELS

03,879 07,83 28,024 00,72 06,7814 00,37

APPENDIX C: ICE THICKNESS DATA, WINOOSKI RIVER.

Middlesex Sta. 25+25

	Position	Ice thi	ckness	Growth	rate	Slush	ice	Snow	cover
Date	from lt.	in.	mm	in./day	mm/day	ft	m	ft	m
1-16-78	35'	6.00	152.40						
1-28-78	3)	12.50	317.50	0.54	13.76	Х			
2-17-78		20.50	520.70	0.47	11.95	X			
2-28-78		28.00	711.20	0.68	17.32	5.28	1.61		
2-17-78	15'	8.00	203.20						
2-28-78	-/	26.00	660.40	1.64	41.56				
1-16-78	85'	5.00	127.00						
1-28-78		11.00	279.40	0.50	12.70	Х			
2-17-78		24.00	609.60	0.76	19.42	1.94	0.59		
2-28-78		25.00	635.00	0.09	2.31	1.82	0.56		
1-16-78	130'	4.00	101.60						
2-17-78		14.50	368.30	0.36	9.20	0.96	0.29		
2-28-78		17.00	431.80	0.23	5.77 .				
				lesex Sta. elier Sta.	45+00 1+00				
1-28-78	35'	11.00	279.40			х			
2-17-78	3)	13.75	349.25	0.16	4.11				
2-28-78		15.75	400.05	0.18	4.62				
1-28-78	70'	8.75	222.25			х			
2-17-78	10	10.00	254.00	0.07	1.87				
2-28-78		12.00	304.80	0.18	4.62				
0 17 70	1051	17.50	000 10			2.65	0.81		
2-17-78 2-28-78	105'	11.50	292.10 336.55	0.16	4.06	2.93	0.89		

WINOOSKI RIVER

Middlesex Sta. 37+50

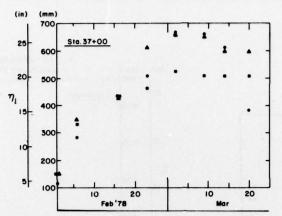
	Position from rt.	Ice thickness		Growth rate		Slush ice		Snow cover	
Date		in.	mm	in./day	mm/day	ft	m	ft	m
1-16-78	40'	5.00	127.00			Х			
1-28-78		10.00	254.00	0.42	10.58				
2-17-78		12.00	304.80	0.12	2.99				
2-28-78		12.00	304.80	0					

Middlesex S	ta. 37+50	(cont'd)					
2-17-78 2-28-78	70'	14.50 18.00	368.30 457.20	0.32	8.08	x 3.55	1.08
			Mida	lesex Sta.	32+00		
1-16-78 2-17-78 2-28-78	25'	5.75 15.25 17.25	146.05 387.35 438.15	0.33 0.18	8.32 4.62	X X	
1-16-78 2-17-78 2-28-78	55'	4.50 14.75 16.25	114.30 374.65 412.75	0.35 0.14	8.98 3.46	x	
1-16-78 2-17-78 2-28-78	80'	5.00 17.50 17.50	127.00 444.50 444.50	0.43	10.95	X	
			Middl	Lesex Sta.	26+50		
1-16-78 1-28-78 2-17-78 2-28-78	30'	7.00 13.00 19.00 19.00	177.80 330.20 482.60 482.60	0.50 0.35 0	12.70 8.96	X X 1.37	0.42
1-16-78 1-28-78 2-17-78 2-28-78	651	5.00 13.25 20.50 23.50	127.00 336.55 520.70 596.90	0.69 0.43 0.27	17.46 10.83 6.93	X X 3.80 3.12	1.16
1-16-78 2-17-78 2-28-78	110'	7.50 17.25 23.00	190.50 438.15 584.20	0.34	8.54 13.28	X X 3.92	1.19
. 27				NOOSKI RI			
			Montp	elier Sta	. 7+00		
2-17-78 2-28-78	35'	10.75	273.05 330.20	0.20	5.20		
2-17-78 2-28-78	70'	12.75	323.85 438.15	0.41	10.39	3.33 3.22	1.02
2-17-78 2-28-78	105'	12.75	323.85 323.85	0		2.58	0.79

Montpelier Sta. 10+00

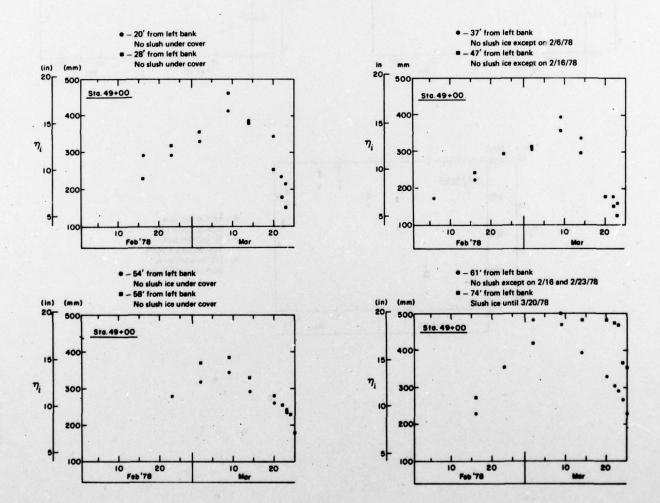
1-28-78 2-17-78 2-28-78	30'	5.00 24.00 22.25	127.00 609.60 565.15		Holes were in the same	
1-28-78 2-17-78 2-28-78	60'	5.00 17.00 16.25	127.00 431.80 412.75	0.47 Not in loca	17.93 same ation	X X
1-28-78 2-17-78 2-28-78	90'	5.00 13.00 15.75	127.00 330.20 400.05	0.47	11.95 6.35	
2-17-78 2-28-78	100'	12.75 19.00	323.85 482.60	0.57	14.43	X X

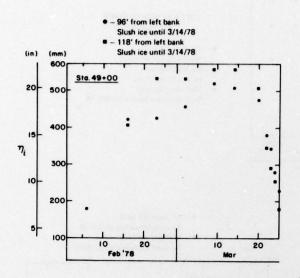
APPENDIX D: GRAPHS OF ICE THICKNESS DURATION, THIRD FREEZE-UP.

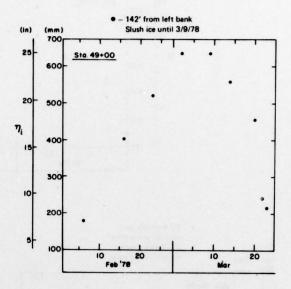


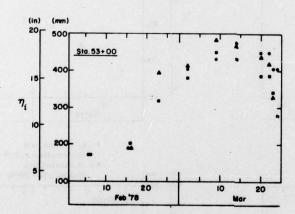
OTTAUQUECHEE RIVER STATION 37+00

- 25' from left bank
 No slush ice under cover
- - 65' from left bank
- Slush ice under cover - 105' from left bank
- Slush ice under cover until 3/2/78









- - 40' from left bank
- Slush ice under cove
- Slush ice under cover

 75' from left bank
 Slush ice until 3/20/78

 115' from left bank
 Slush ice until 3/2/78